

B. Low-Cost Test Methods for Advanced Automotive Composite Materials; Creep Compression Fixture

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Objective

- Design and develop low-cost, reliable fixtures and methods for the characterization of compression creep behavior of automotive composites with and without environmental exposure. Confirm results generated by the new fixture with those from conventional testing systems.
- Incorporate the fixtures and methods in the above objective into industry-standard test methods for automotive composites.
- Using results of short-term tests, develop predictive models for lifetime property degradation.
- Investigate the fundamental damage mechanisms in polymer-matrix, carbon-fiber, and E-glass composites as a function of specific, varied mechanical loading with concurrent environmental exposure.

Approach

- Design and develop a compact compression creep test fixture system and confirm its performance.
- Use the new fixture system to develop a compression creep database.
- Develop a standard procedure for compression creep testing using the new system.
- Develop and verify damage and creep models for structural automotive composites.

Accomplishments

- Developed, fabricated, and tested initial fixture prototype and isolated problem areas.
- Designed, developed, and fabricated two new fixtures to enhance capability of first-generation prototype.
- Fabricated second prototypes and performed initial prove-out testing.
- Implemented new data acquisition system.

Future Directions

- Continue prove-out of fixture system.
- Evaluate varying environments on the fixture system and the test materials.
- Design and develop additional fixtures if required.
- End project on 12-31-2005.

Introduction

Because of insufficient information on the long-term durability of lightweight composite materials, reliable methods and models requiring relatively short-term tests are essential to composites achieving their full potential in the automotive industry. The purpose of this project is to develop simple low-cost fixtures and methods for the creep and creep rupture characterization of automotive composites and confirm the in-situ creep test fixture results with those obtained using conventional testing methods.

Initial Design Concept For The Compression Creep Fixture

Several design specifications were targeted when developing the initial prototype fixture. It must simulate in-service loading conditions by exposing the specimen

to various environments. The fixture should also be lightweight, compact, relatively inexpensive, and portable compared to industry standard deadweight creep testing fixtures. Lastly, the data generated by the fixture should be of design quality while comparing favorably to Oak Ridge National Laboratory (ORNL) and literature data. A successful fixture would also be corrosion-resistant, capable of testing American Society of Testing and Materials (ASTM) standard compression coupons, and exhibit no signs of specimen buckling.

Prototype 1 Design Details

The initial prototype utilizes a four-pin design where the specimen fits inside two compression blocks that are pressed toward each other by load reversing pins. The ends of the pins are threaded into a connecting bracket that, in turn, mounts to a clevis joint on a spring-loaded moment arm (see

Figures 1, 2, and 3). This prototype is capable of testing compression specimens up to 2.5 in. in length. This is exactly one-half of the ASTM standard length. The second set of prototypes is designed to use the full-sized specimen.



Figure 1. Compression Blocks with 2.5 in. specimen.

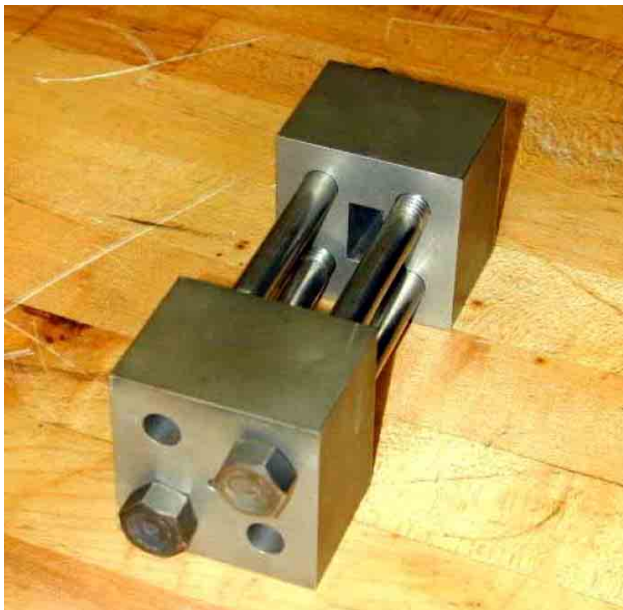


Figure 2. Compression blocks assembled with load reversing bolts.

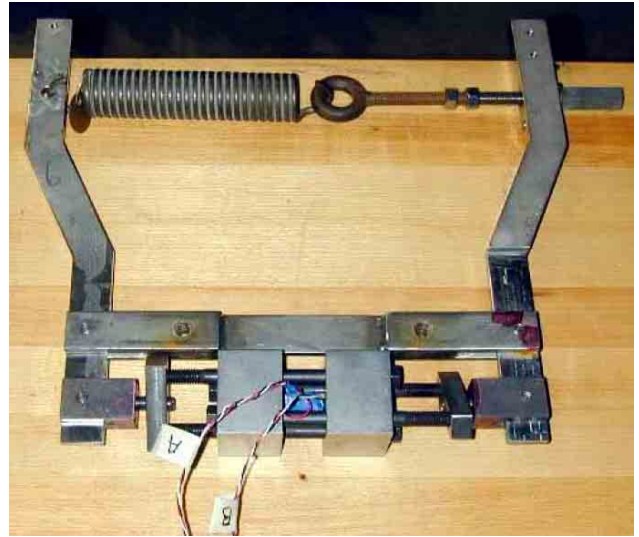


Figure 3. Assembled prototype #1 compression creep fixture.

Prototype 1 Test Results

Initial testing of P4 glass material with prototype 1 showed compression creep behavior very similar to the compression creep curves generated by ORNL (see Figure 4). When a strain gage was mounted on each side of the compression specimen a difference in strain levels was shown (see Figure 5). This indicates a bending load being placed on the specimen. ASTM requires compression tests to exhibit less than 5% bending to be considered valid. The bending is attributed to end loads placed on the specimen by the compression blocks and misalignment of the specimen in the pockets. Because of these bending loads, a new design is required.

Prototype 2a Design Details

After determining that a second prototype was necessary, two alternatives were designed and fabricated. Prototype 2a uses compression blocks and load reversing pins very similar to those used in prototype 1; 2a has an added feature of two bolts through the side of the compression blocks that fit to a gripping pad. When the 5-in. compression specimen is loaded into the compression blocks the two bolts can be tightened to

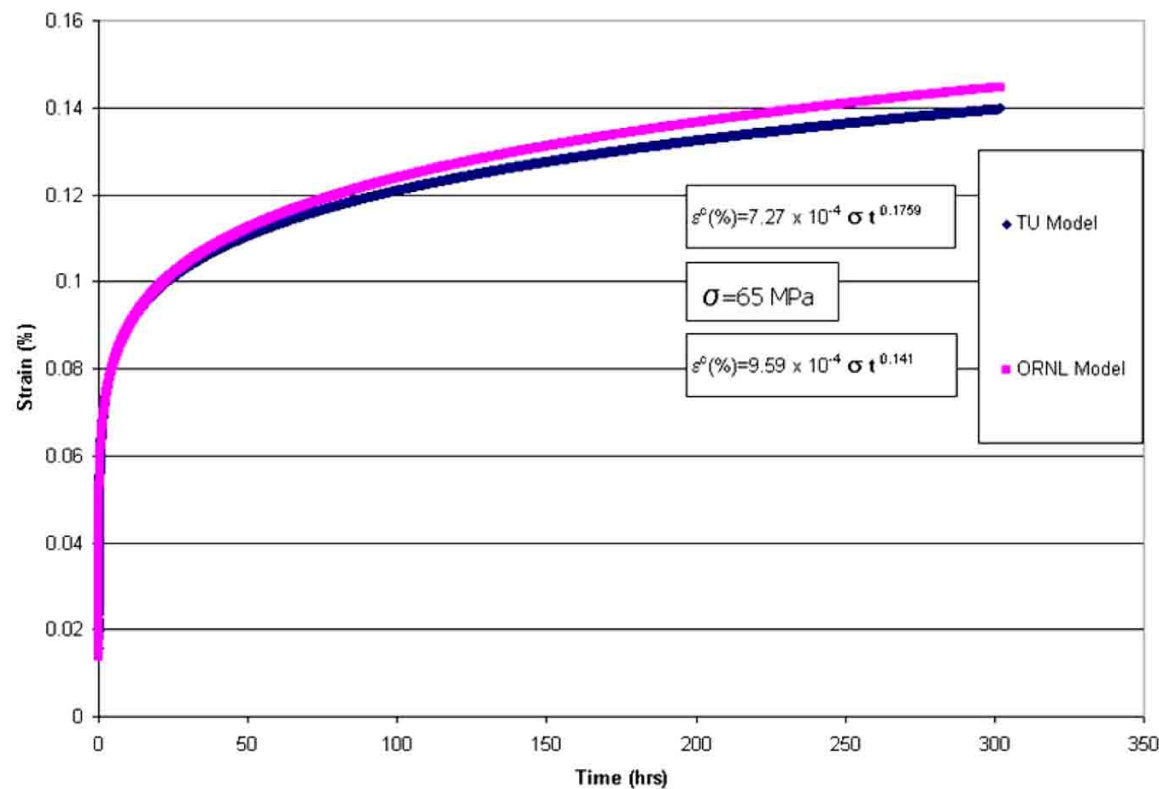


Figure 4. Preliminary creep data from prototype 1 and ORNL experiments.

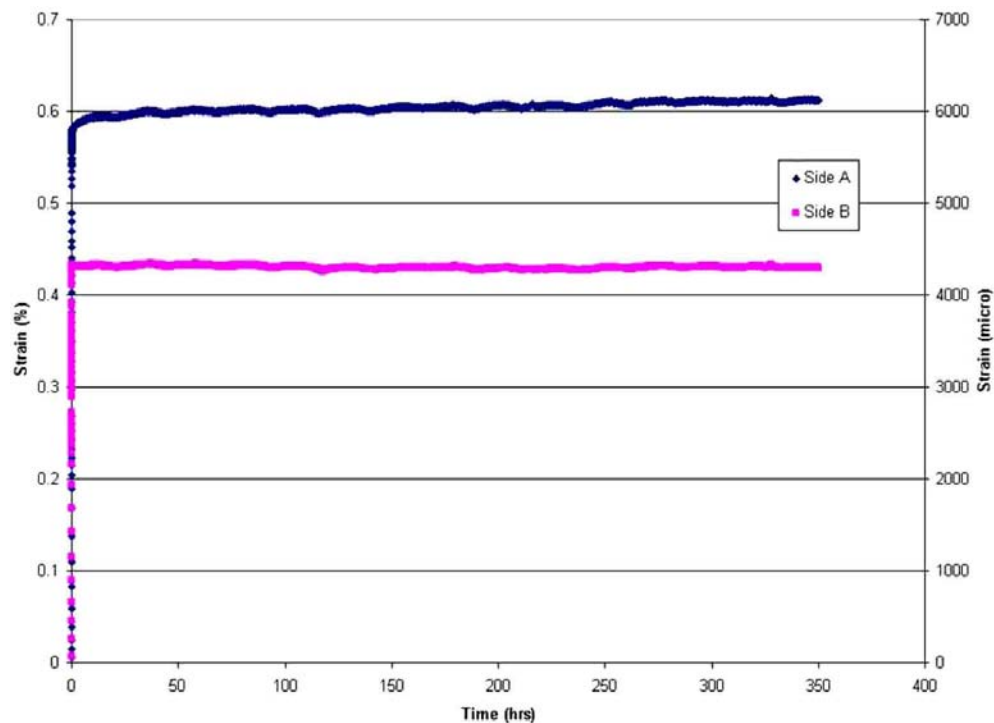


Figure 5. Differences in strain levels on each side of the specimen indicating bending.

align and hold the specimen in the compression blocks (see Figures 6 and 7).



Figure 6. Fixture 2a components.

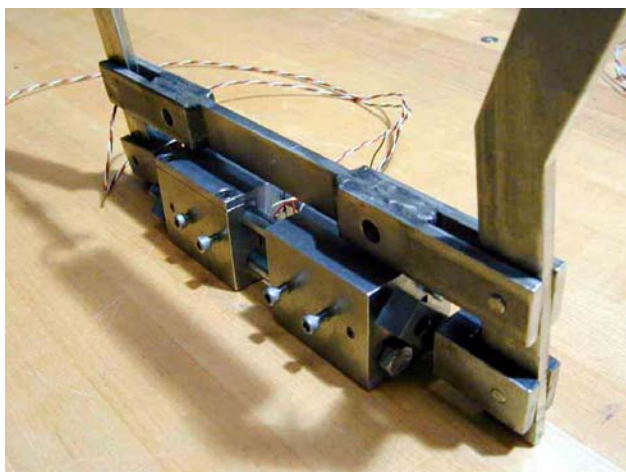


Figure 7. Fixture 2a with loaded specimen.

Prototype 2b Design Details

Prototype 2b utilizes four wedge-shaped grip faces. As the compression blocks are pressed toward each other with load reversing pins, the wedge grips squeeze the 5-in. compression specimen with increasing pressure. This fixture design utilizes symmetry and the compression force being placed on the specimen to eliminate bending and end loading of the specimen (see Figures 8 and 9).



Figure 8. Fixture 2b components.

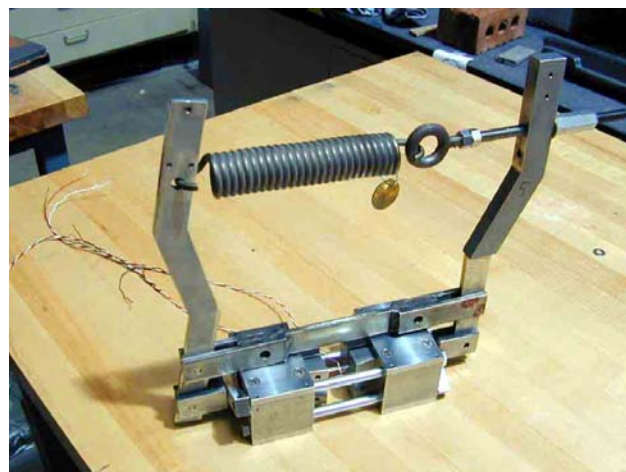


Figure 9. Fixture 2b with spring-loaded moment arms.

Ongoing/Future Work

- Continued evaluation of prototype 2a and 2b performance through short-term tests, using composite and aluminum specimens.
- Determination of a final prototype able to meet all design requirements and criteria.
- Refining of final prototype.
- Fabrication of a series of compression fixtures for evaluation of polymer composite material systems.
- Creep, stressed environmental durability, and in-service testing using the creep compression fixture.